Lean, TOC & 6 Sigma; An Overview

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Why are Mfg Systems so hard to manage?

- **Interactions**
- **Time lags**
- **Non-linearities**
- **People**
- **Conflicting Goals**
- **Leverage Effects**
- **Short-term vs. Long-term benefits**
- **Effect of uncontrollable external forces**

CLASSIC SYSTEMS BEHAVIOR!

A COMPLEX, TIGHTLY COUPLED NETWORK

How Do We Attack this Complexity?

- **Lean – Toyota Production System**
- **Theory of Constraints – Eli Goldratt**
- **6 Sigma - Motorola**

Lean, TOC and 6 Sigma (with medical analogies)

- *They are complementary; you can do all three*
- *Lean is a holistic, enterprise wide system; an excellent HMO. Lean focuses on waste elimination and customer value. It is THE most powerful approach.*
- *TOC is a stochastic, network approach to obtain the lean goals of reduced cycle time and continuous flow; an excellent hospital. TOC focuses on bottleneck elimination and total system optimization.*
- *6 Sigma is a suite of specialized tools, organized on a project basis to solve a particular problem; an excellent surgeon. 6 Sigma focuses on variability reduction of key design features and manufacturing processes.*

WHAT IS LEAN ?

- **Lean is the Toyota Production System**
- Lean systems use less of everything…half the people…half the space…half the inventory…half the investment…half the engineering effort…
- Lean means right thing, right place, right time, right quantity
- A lean system adds value by eliminating waste, being responsive to change, focuses on quality and enhancing the effectiveness of the workforce
- Lean systems focus on maximizing the value stream while eliminating all waste
- **Lean is a <u>way of thinking</u> that focuses on constantly shortening the order to delivery time by maximizing the flow of information and material while reducing cycle time.**

Lean is a System

- Product Development
- Manufacturing
- Supply Chain

Customer Focus at the CORPORATE LEVEL

- HIGHEST QUALITY
- LOWEST COST
- SHORTEST LEAD TIME

Lean Priorities at the FACILITY Level

1. Environmental Safety and Occupational Health

2. QUALITY

3. PRODUCTIVITY

4. COST

Operating Philosophies on the SHOP FLOOR

- **MAKE ONLY WHAT IS NEEDED**
- **NEVER PRODUCE A DEFECT – NEVER PASS A DEFECT ON**
- **ELIMINATE ALL WASTE**

FOCUS ON FLOW AND CYCLE TIME REDUCTION

What is Waste?

- ***Waste is anything that does not add value for the customer or ……..***
- ***Anything your customer is not willing to pay more for.***

The Seven Wastes in Manufacturing

1. **Over Production--Producing more material than is needed before it is needed is the fundamental waste in lean manufacturing.**
2. **Excess Inventories--Material sits taking up space, costing money, and potentially being damaged. Problems are not visible.**
3. **Waiting--Material waiting increases lead time and cost without adding value to the product.**
4. **Producing Defective Products--Defective products cause rework, impede work flow and lead to wasteful handling, time, and effort.**
5. **Wasted Employee Motion--Toolrooms.**
6. **Transportation--Moving material between work sites does not add value.**
7. **Over-Processing--Over engineering, inspections, layers of document review, unnecessary requirements.**

VALUE

- *The customer must be willing to pay for it*
- *It must transform the product*
- *It must be done right the first time*
- *If you pulled this step, would the customer miss it?*

Summary of the TPS (Lean)

- *It always begins with the customer*
- *The customer wants the right thing, at the right time, right place, right price, with perfect quality: value*
- *Value is always the end result of a process*
- *Each process step must contain zero waste*
- *To achieve zero waste, each process step much be valuable, capable, available, adequate and flexible*
- *A truly lean process is a perfect process*
- *Perfection is not possible, but lean enterprises behave as if it is*

Theory of Constraints

Eli Goldratt
Israeli Physicist

Manufacturing facilities are a stochastic network

THEORY OF CONSTRAINTS (TOC) / SYNCHRONOUS MANUFACTURING PRINCIPLES

The Action You're Proposing:

--Will It Increase Throughput (SALES)?

--Will It Decrease Inventory?

--Will It Decrease Operating Expense?

-Goldratt-

Business Rationale for Theory of Constraints (TOC)

Making Product ≠ Making $

People Working ≠ Making $

If You didn't Sell it!

Until You Sell what they worked on!

Manufacturing Goals

- Throughput (Sales) ↑
- Inventory & WIP ↓
- Operational Expense ↓

Simultaneously

Result In:

- NET Profit ↑
- ROI ↑
- Cash Flow ↑

Mfg Facilities are Systems/Networks

- ***Be a systems thinker***
- ***The system optimum is not the sum of the local optima***
- ***Systems are analogous to chains (weakest link)***
- ***Systems operate according to the Pareto Principle (bottlenecks: physical or policy)***

"SUM OF THE LOCAL OPTIMUMS $\neq$ GLOBAL OPTIMUM"

- BALANCE FLOW NOT CAPACITY
- BOTTLENECKS GOVERN BOTH THROUGHPUT AND INVENTORIES
- AN HOUR LOST AT A BOTTLENECK IS AN HOUR LOST FOR THE ENTIRE SYSTEM
- AN HOUR SAVED AT A NON-BOTTLENECK IS A MIRAGE
  - THE POTENTIAL OF A NON-BOTTLENECK IS NOT DETERMINED BY ITSELF BUT BY THE BOTTLENECKS
- IF YOU DON'T NEED A PART, DON'T MAKE IT. IT IS OK TO LET NON-BOTTLENECKS SIT IDLE.
- NEVER LET BOTTLENECKS SIT IDLE

"BOTTLENECKS PACE THE PLANT"

1. The output of upstream operations control the output of downstream operations.
2. The cycle times of all work centers varies -- this variability spreads through all downstream operations.

Therefore:

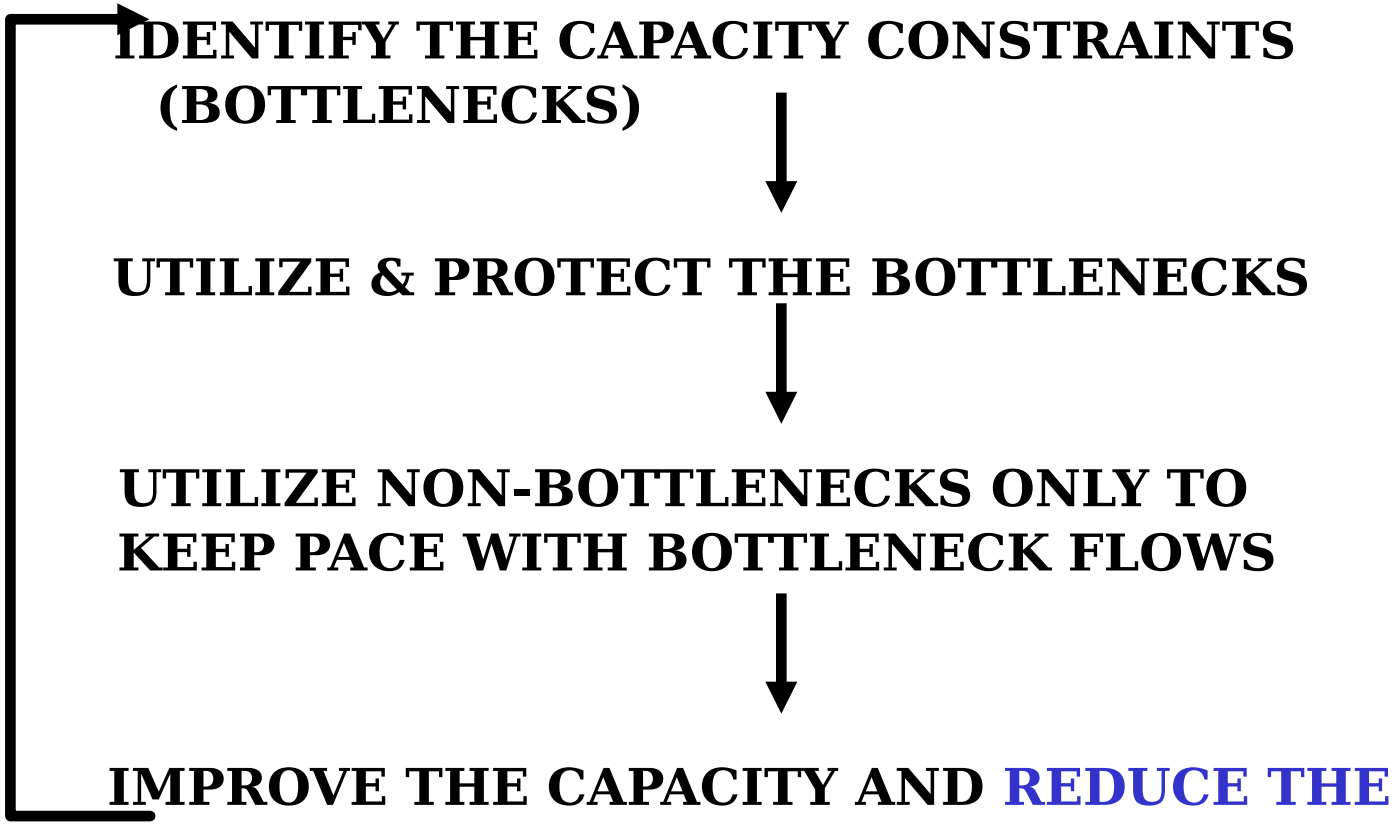
The maximum deviation of a preceding operation will become the starting point of a subsequent operation.

Or:

1. Work Centers with excess capacity cannot work on parts they cannot get.
2. Bottlenecks cannot work on additional parts when they are already at 100% capacity.
3. Fluctuations in bottleneck outputs only make things worse.

A	→	B	→	Output
1 per hr	→	100 per hr	→	?
100 per hr	→	1 per hr	→	?

The Theory of Constraints (TOC) Process


IDENTIFY THE CAPACITY CONSTRAINTS (BOTTLENECKS)
UTILIZE & PROTECT THE BOTTLENECKS
UTILIZE NON-BOTTLENECKS ONLY TO KEEP PACE WITH BOTTLENECK FLOWS
IMPROVE THE CAPACITY AND REDUCE THE VARIABILTY OF EXISTING BOTTLENECKS

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6 Sigma

OPERATING EXCELLENCE MEANS LEAN PROCESSES WORKING AT SIX SIGMA QUALITY LEVELS

MIKE JOYCE
LOCKHEED-MARTIN 21

GE's Definition of Six Sigma

Six Sigma is the disciplined methodology of defining, measuring, analyzing, improving and controlling the quality in every one of the Company's products, processes and transactions-with the ultimate goal of virtually eliminating all defects.

"This is the most important initiative this Company has ever undertaken. (It) will fundamentally change our Company forever".

John F. Welch, JR.

Defining Six Sigma

• A business initiative that employs specialized engineering and statistics on a project-by-project basis:

- uses financial measures to select projects

- uses financial measures to determine success

- attacks variation in products, processes and services

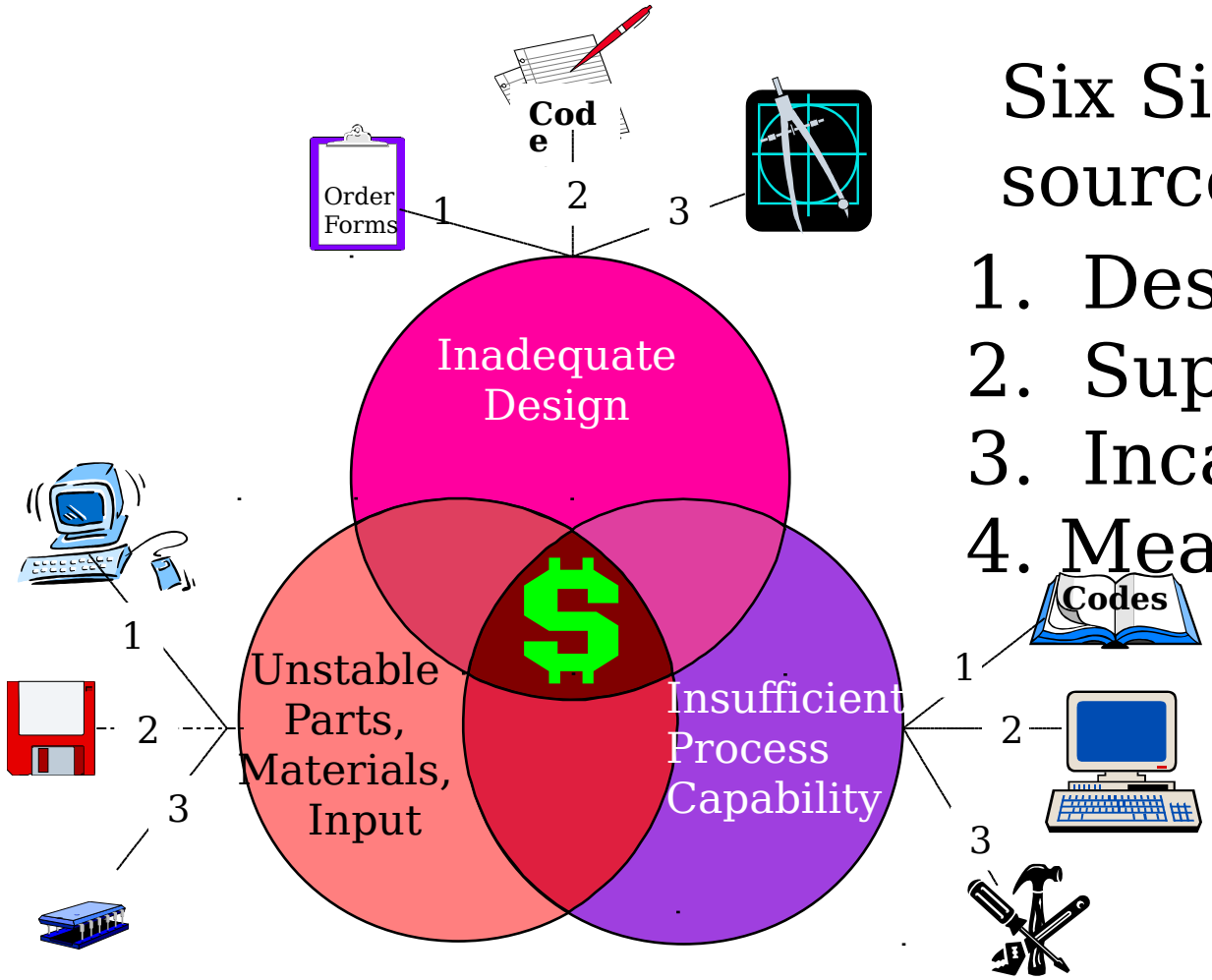
- has the goals of increased profitability and ROI

- requires leadership, training, infrastructure, tools and methods

• 3 ppb < Defects < 3.4 ppm at the ***component*** level

It is NOT a systematic, holistic approach like Lean

What is Six Sigma?



Region of Six Sigma Synergy

Six Sigma attacks sources of variability i

1. Design
2. Suppliers/Vendors
3. Incapable processes
4. Measurement

SIGMA BENCHMARKS

		DPMO
• IRS Phone-in tax advice	2.2σ	241,964
• Restaurant bills, doctor's bills, prescription writing, and payroll processing	2.9σ	80,757
• Average manufacturing Company	3.0σ	66,807
• Airline baggage handling	3.2σ	44,565
• Best-in-class companies	5.7σ	13

Why Did it Start? **BUSINESS SURVIVAL !**

- Late 70's Vs Motorola TVs; "Our quality stinks…"/ Japanese buyout

- 1984: Bill Smith of Motorola

  - system complexity

  - process variability and drift

  - the effect of factory rework on system reliability

- 1985: Mikel Harry of Motorola - use of statistics to improve quality

- 1990: * Motorola Bandit Pager

  How do we get a "true" 99% "first-pass" yield of pagers, where each pager has 2000 components ?

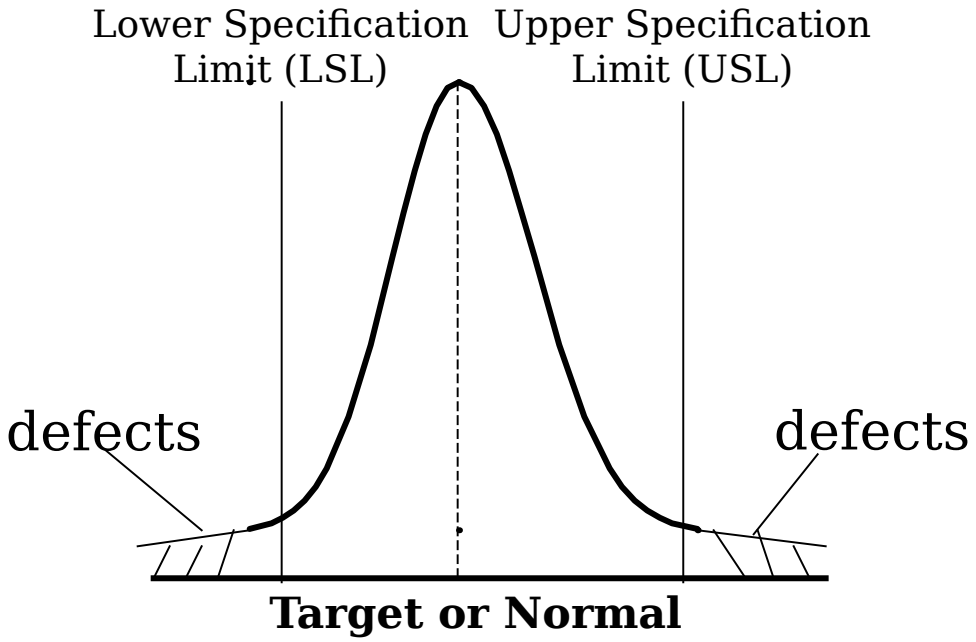
- Rolled Yield Throughput:

We need $Y^{2000} = 0.99$

Variation Creates Defects

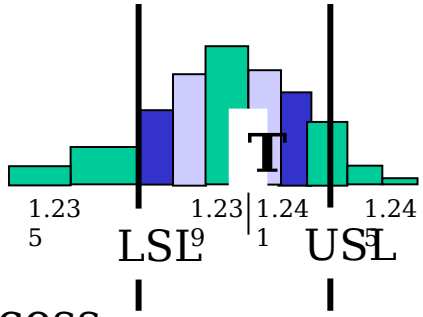
Six Sigma is all about Variation

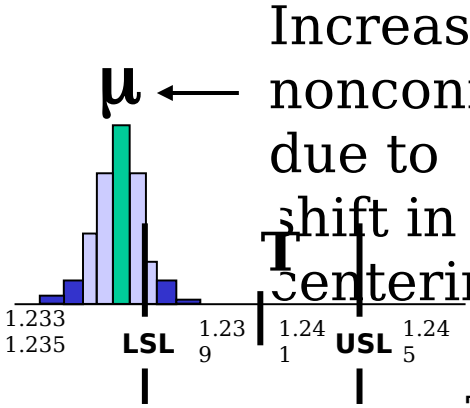
Process/Product performance, i.e., variation from the target value as depicted as a normal distribution



The Basics

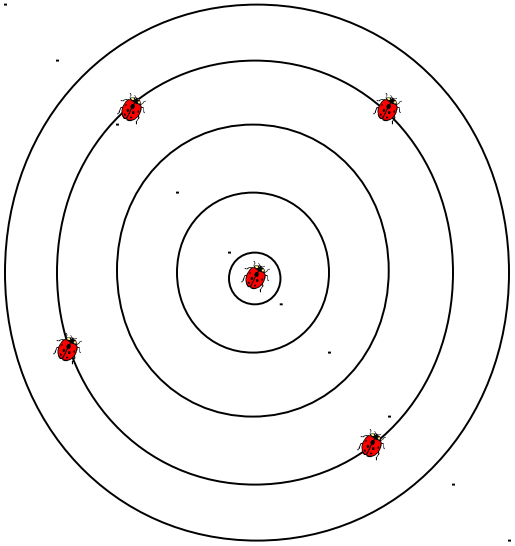
We desire a centered process with little variability

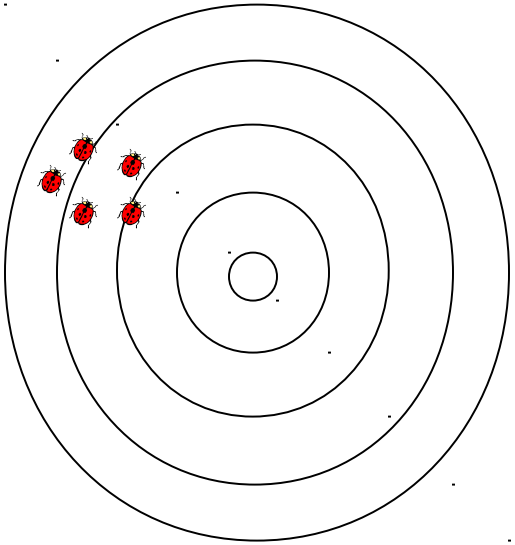




Increase in nonconformance due to shift in process centering

The process width is independent of the design width.



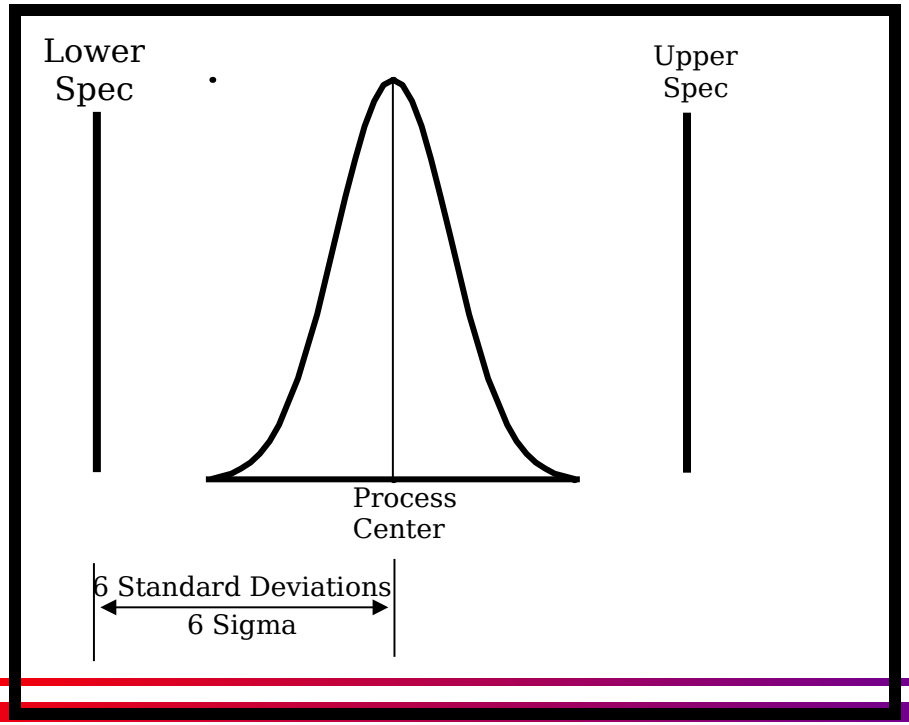


The process center is independent of the design center.

What is Six Sigma?

Variation is the Enemy

- Sigma refers to standard deviation, measure of variation.
  - **Six Sigma refers to a process having six standard deviations (short term) between the process mean and the nearest specification limit.**



Continuously.....

- Improve yields
- Eliminate defects
- Reduce the cost of poor quality and
- Reduce cycle time

.....for each process

Six Sigma Tools

- **Applied Statistics**

SPC/ DOE/ ANOVA/ Regression/ Confidence Testing

- **Basic Analytical Tools**
- **Process Capability & Process Performance**
- **Measurement Systems Analysis(Gauge Repeatability & Reproducibility) <u>One of the first tech issues to be checked ! 20% -25%</u> ?**
- **Reliability Engineering**

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